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(54) Title of the invention: Film thickness measurement apparatus

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Specification

1. Title of the invention: Film thickness measurement apparatus

2. Claims

A film thickness measurement apparatus provided with a sample platform on which a sample on whose surface a thin film has been formed is to be placed, a first light-emitting means for directing a light to the sample on said sample platform at a first incident angle, a first sensor for detecting the light from the aforementioned first light source reflected at the surface of the aforementioned sample, a second light-emitting means for directing a light

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having the same wavelength as that emitted from the aforementioned first light-emitting means to the sample on said sample platform at a second incident angle, a second sensor for detecting the light from the aforementioned second light source reflected at the surface of the aforementioned sample, a computation means for computing a film thickness value for each ellipsometric period based on the signals output from the aforementioned first and second sensors, and a comparison means for determining the true film thickness value by comparing the computation results of this computation means.

3. Detailed explanation of the invention

[Technical field of the invention]
The present invention relates to a film thickness measurement apparatus for measuring the thickness of a thin film such as an oxide film, nitride film, or poly-crystalline silicon film formed on a semiconductor wafer, etc., or of a thin film having a short ellipsometric period.

[Technical background of the invention and the problems to be addressed]
Figure 3 shows an example of a conventional film thickness measurement apparatus that utilizes ellipsometry. This apparatus is provided with a pair consisting of a light source 1 that emits a light beam of a predetermined wavelength and a sensor 2 that detects the reflected light beam. A sample 3, on which a thin film has been formed, is placed on a sample platform 4. However, with this apparatus, when a measurement is to be made, the person taking the measurement must change the angle of the light source in order to change the incident angle of the light beam, as indicated by dotted lines in Figure 3, and must determine the film thickness from the film thickness measurement values for various ellipsometric periods that are obtained at various angles and that have the same value. Consequently, the operation required is complex.

Besides such an apparatus, an apparatus has also been used that has two pairs of light sources for emitting light beams of differing wavelengths and sensors for detecting the light beams reflected from the light sources. However, with such an apparatus, while the light beam having one of the wavelengths is stable, the one having the other wavelength is unstable and its life span is short, resulting in lack of reliability.

[Objective of the invention]
The present invention has been developed in view of the aforementioned situation, and its objective is to provide a thin film measurement apparatus that can simply and accurately measure the thickness of a film that has been formed on the surface of a sample.

[Overview of the invention]
In order to achieve the aforementioned objective, the present invention provides a film thickness measurement apparatus, provided with at least two pairs each consisting of a light

source positioned so as to emit light beams at different incident angles and a sensor for detecting each reflected light, that emits light beams having the same wavelength from the individual light sources, and that determines the film thickness from the numerical values obtained using the individual light beams emitted.

(Embodiment)

An embodiment of the present invention will be explained below with references to Figures 1 and 2.

In the embodiment shown in Figure 1, two light sources 1a and 1b are provided, and two sensors 2a and 2b for detecting the reflected light are also provided. That is, the light sources 1a and 1b and the sensors 2a and 2b are provided as two pairs. All of these items are secured above a sample 3, such as a semiconductor wafer, to be placed on a sample platform 4; light source 1a is set so as to emit a light beam at an incident angle of 70 degrees from the normal line of the sample 3, while the other light source 1b is set so as to emit a light beam at an incident angle of 30 degrees from the normal line of the sample 3. Therefore, the sensors 2a and 2b, which detect the reflected light from the light sources 1a and 1b, are also set at like angles from the normal line.

The light beams emitted from the light sources 1a and 1b are reflected by the thin film that has been formed on the top surface of the sample 3 and by the surface of the sample, and are detected by the sensors 2a and 2b, and in this way the film thickness is measured. Here, the light beams emitted from the light sources 1a and 1b have the same wavelength. For such light beams, those that are stable and have excellent reflective characteristics, such as helium-neon laser, are selected. Using a light beam having a stable wavelength enables accurate measurements and extends the life span of the light source.

The film thickness is measured using the ellipsometric method. That is, as shown in Figure 2, the reflected lights from the two light sources 1a and 1b are detected by the sensors 2a and 2b, and predetermined arithmetic operations are applied to the detected data by arithmetic operation units 5a and 5b. The periodicity values thus obtained are compared with each other by a comparison operation unit 6, and when two values match each other, that value can be used as the true film thickness. This true film thickness value is displayed on a display device 7. In this case, since the measurement method is the same as that used conventionally, measurement control and data processing can be simply performed by modifying the personal computer programs or the like that comprise the arithmetic operation units 5a and 5b and the comparison operation unit 6.

Next, a case will be explained in which the film thickness of an oxide film that has been formed on a silicon wafer 3 and that has a refractive index of 1.45 and a thickness of 6,000 Å is measured using a device in which light sources 1a and 1b are set such that helium-neon

lasers with a wavelength of 6,328 Å enter the sample 3 at incident angles of 30 and 70 degrees. The following values have been detected by sensor 2b for the light that is emitted from light source 1b at an incident angle of 30 degrees and reflected from the sample:

1,351 Å, 3,675 Å,
6,000 Å, 8,325 Å …

indicating a period of 2,325 Å. Meanwhile, the following values have been detected by sensor 2a for the light that is emitted from light source 1a at an incident angle of 70 degrees and reflected from the sample:

270 Å, 3,135 Å,
6,000 Å, 8,865 Å …

indicating a period of 2,865 Å. Therefore, the film thickness obtained from the measurements is determined to be 6,000 Å since that is the value at which the two kinds of measurement values match, resulting in accurate film thickness data.

Note that in the present invention, it is acceptable to provide three or more pairs of light sources and sensors, which can improve the accuracy and shorten the measurement time. Furthermore, the incident angles for the light beams are not restricted to those described in the embodiment, and can be varied in various ways.

[Effects of the invention]

As explained above, because the present invention is provided with at least two pairs of a light source positioned so as to emit light beams at different incident angles and with a sensor for detecting each reflected light, and emits light beams having the same wavelength from the individual light sources, it can provide a film thickness measurement apparatus that can measure film thickness simply and accurately and that can perform continuous measurements at high speeds.

4. Brief explanation of drawings

Figure 1 is the front view of the key area of an embodiment of the present invention; Figure 2 is a block diagram illustrating the configuration of the embodiment; and Figure 3 is the front view of the key area of a conventional apparatus.

1a and 1b … Light sources; 2a and 2b … Sensors; 3 … Sample

Agent: Kazuo Sato, patent attorney

Figure 1

Figure 2
2a: Sensor
5a: Arithmetic operation unit
2b: Sensor
5b: Arithmetic operation unit
6: Comparison operation unit
7: Display device

Figure 3

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審査請求 未請求 発明の数 1 （全3頁）

㊹発明の名称　膜厚測定装置

㉑特　願　昭60-168023
㉒出　願　昭60(1985) 7月30日

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明　細　書

1. 発明の名称　膜厚測定装置

2. 特許請求の範囲

表面に薄膜が形成された試料を置く試料台と、この試料台上の試料に対して第1の入射角度で光を照射する第1の光照射手段と、前記試料面で反射された前記第1の光照射手段からの光を検出する第1の検出手段と、前記試料台上の試料に対して第2の入射角度で前記第1の光照射手段と同一波長の光を照射する第2の光照射手段と、前記試料面で反射された前記第2の光照射手段からの光を検出する第2の検出手段と、前記第1および第2の検出手段の出力信号にもとづいてエリプソメトリ周期毎の膜厚値を演算する演算手段と、この演算手段の演算結果をそれぞれ比較して真の膜厚値を求める比較手段とを備える膜厚測定装置。

3. 発明の詳細な説明

〔発明の技術分野〕

本発明は半導体ウェーハ等の上に形成された酸化膜、窒化膜、多結晶シリコン膜等の薄膜や、エリプソメトリ周期が短かい膜種の膜厚を測定する膜厚測定装置に関する。

〔発明の技術的背景とその問題点〕

エリプソメトリを利用した膜厚測定装置の従来例を第3図に示す。一定波長の光線を照射する光源1と、反射された光線を検知する検知器2とが1対配設されている。試料3は試料台4の上に載置されており、試料3の表面には薄膜が形成されている。しかしながらこの装置では、測定に当っては第3図に点線で示すように光線の入射角を変化させるため光源の角度を測定者が変え、各角度で測定して得られたエリプソメトリ周期毎の膜厚値から、数値が同一の測定値を膜厚として求めなければならない。このため、操作が煩雑である。

このような装置の他に、異なる波長の光線を照射する光源と、各光源からの光線が反射された光

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線を検知する検知器とが2対配設されたものが、従来から使用されている。しかしながらこの装置では、照射される光線のうちの一方の波長の光は安定であるが、他方の波長光は不安定で寿命が短かく、信頼性に欠けている。

(発明の目的)

本発明は上記事情を考慮してなされたもので、試料表面に形成された膜の厚さの測定を簡単に、しかも正確に行なうことができる膜厚測定装置を提供することを目的としている。

(発明の概要)

上記の目的を達成するため本発明は、照射する光線の入射角が異なるように配設された光源と、各反射光を検知する検出器とが少なくとも2対配設されており、各光源から同一波長の光線を照射し、それぞれの光照射で得られた数値から膜厚を測定する膜厚測定装置を提供するものである。

(発明の実施例)

以下、本発明の一実施例を第1図および第2図を参照して説明する。

第1図に示す実施例では、光源1a，1bが2基設けられ、反射光の検出器2a，2bが2基設けられている。すなわち、光源1a，1bと検出器2a，2bの組が2対配設されている。これらはいずれも試料台4上に載置される半導体ウェーハ等の試料3の上方に固定され、一方の光源1aは試料3の法線に対して70度の入射角で光線を照射するようにセットされ、他方の光源1bは法線に対して30度の入射角で光線を照射するようにセットされている。従って、各光源1a，1bに対応して反射光を検知する検出器2a，2bも、法線に対してそれぞれ同様の角度でセットされる。

光源1a，1bから照射された光線は、試料3の上面に形成された薄膜および試料面で反射されて検出器2a，2bに検知され、これにより膜厚が測定される。ここで、各光源1a，1bから照射される光線としては同一波長のものが使用される。この波長光としては安定性がよく、しかも反射性のよいものが使用され、例えばヘリウム-ネオンレーザ光が選択される。安定した波長光を使用することで正確な測定が可能となり、しかも光源の寿命が長くなる。

膜厚の測定はエリプソメトリ法で行なわれる。すなわち第2図に示すように、2つの光源1a，1bの反射光を検出器2a，2bで検出し、この検出データに対して演算装置5a，5bで所定の演算処理を施す。このようにして得られた周期数値を比較演算装置6で比較し、それぞれの数値が一致したものを真の膜厚とすることができる。この真の膜厚値は表示装置7で表示される。この場合、測定方法は従来と同様であるので、測定の制御およびデータ処理は演算装置5a，5bおよび比較演算装置6を構成するパーソナルコンピュータ等のプログラムを変更するだけで簡単に行なうことができる。

次に、波長6328Åのヘリウム-ネオンレーザを、試料3に対して入射角30度、70度となるように光源1a，1bをセットした装置を使用して、シリコンウェーハ3上に形成された屈折率1.45、膜厚6000Åの酸化膜の膜厚を測定する場合を説明する。光源1bから入射角30度で照射され、試料で反射された光を検出器2bで検知した数値は、

1351Å，3675Å，

6000Å，8325Å…

であり、2325Åの周期となる。光源1aから入射角70度で照射され、反射した光を検出器2aで検知した数値は、

270Å，3135Å，

6000Å，8865Å…

であり、2865Åの周期となる。従って、測定によって得られる膜厚は上記2種の数値が一致した6000Åとなり、正確な膜厚データが得られる。

なお、本発明においては光源と検出器を3対以上設けてもよく、これにより精度の向上と測定時間の短縮が可能となる。又、光線の入射角度も図示の実施例に限らず、種々変更が可能である。

(発明の効果)

以上の通り本発明によれば、異なる入射角で光

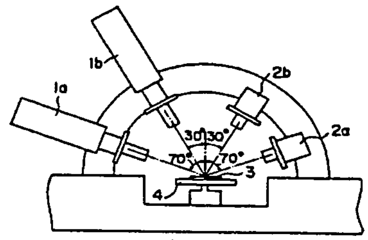
線を照射する光源と反射光を検知する検出器を少なくとも2基対以上配設し、各光源から同一波長の光線を照射するようにしたので、膜厚の測定が簡易に、しかも正確に行なうことができ、連続測定を迅速に行なうことができる膜厚測定装置が得られる。

4．図面の簡単な説明

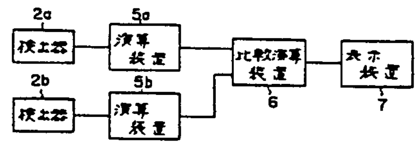
第1図は本発明の一実施例の要部の正面図、第2図は同実施例の構成を示すブロック図、第3図は従来装置の一例の要部の正面図である。

1a，1b…光源、2a，2b…検出器、3…試料。

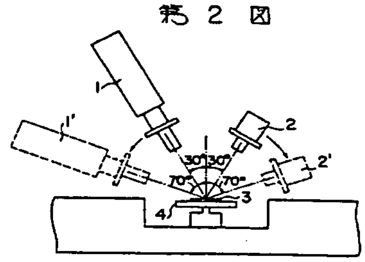
出願人代理人　佐　藤　一　雄



第1図



第2図



第3図

FILM THICKNESS MEASURING INSTRUMENT

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Inventor(s): MAEDA TORU
Applicant(s): TOSHIBA CORP
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IPC Classification: G01B11/06; H01L21/66
EC Classification:
Equivalents:

Abstract

PURPOSE:To easily and accurately measure the thickness of a film, by providing at least two pairs of a light source which irradiates rays of light at different incident angles and a detector for detecting reflecting light and irradiating rays of light of the same wavelength from each light source.

CONSTITUTION:Two sets of light sources 1a and 1b and two sets of reflecting light detectors 2a and 2b are provided. Rays of light having the same wavelength are used as those irradiated from the light sources 1a and 1b. The reflecting lights from the two light sources 1a and 1b are respectively detected with the detectors 2a and 2b and arithmetic units 5a and 5b perform prescribed operation processes on the detected data. The periodicity values thus obtained are compared with each other at a relational arithmetic unit 6 and the one when the two values coincide with each other is used as the true thickness of a film. The value of the true film thickness thus obtained is displayed through a display device 7. Therefore, the thickness of a film can be measured easily and accurately.